SPRINKLER CONFIGURATION FOR OVERHEAD IRRIGATION SYSTEMS

This article is a summary of the content in a publication from the Proc. of the 30th Annual Central Plains Irrigation Conference held Feb. 20-21, 2018. The authors are Steve Melvin and Derrel Martin of the Univ. of Nebraska. The publication is titled "In-Canopy vs. Above-Canopy Sprinklers: Which is Better Suited to Your Field?" The publication is presented in three parts, which are: Part 1 [water losses from a center pivot]; Part 2 [basic sprinkler package design]; and Part 3 [differences between in-canopy and above-canopy sprinklers]. Mr. Melvin has also composed a Power Point presentation that contains the contents of the above articles.

The following points are highlights of information contained in the above articles, and are related to the efficiency of overhead irrigation systems. The specific data and findings reported in this article are from research conducted in the Great Plains region of the U.S., so they may not directly transfer to overhead irrigation conditions in the humid sub-tropical Midsouth. However, they do highlight items that should be considered for overhead irrigation applications in any environment.

In the above article, the authors highlight consequences of sprinkler design choices and how those decisions affect uniformity of water application, application efficiency, and the quantity of irrigation water lost from overhead system applications. Selecting the proper sprinkler package for an overhead irrigation system is essential to ensure the most efficient operation of these systems. An important component of this process is the placement of sprinklers in or above the canopy of the crop being irrigated–i.e. the mounting height of the sprinklers in relation to the top of the crop being irrigated.

- Water losses from or low application efficiency of overhead irrigation systems result from several factors that include: 1) droplet evaporation while the water is traveling through the air; 2) drift of water droplets from the site of application; 3) evaporation of applied water from the wetted crop leaves; 4) evaporation of applied water directly from exposed soil; and 5) non-uniform application which results in runoff from the field or into low field areas.
- Improving application efficiency of irrigation water is the goal of determining the best position of sprinkler devices in relation to the crop canopy.

The authors cite results from research conducted at Bushland, Texas. The details of that research follow.

- Experiments were conducted during the middle of the day with temperatures of 88°F, wind speeds ≥ 15 mph, and ~36% relative humidity. Water supply rate was about 6 gal./min./acre with one inch of water applied after a corn canopy had reached its full height.
- Sprinkler package efficiencies were: 1) about 88% from impact sprinklers on top of the pivot pipeline; 2) about 92% from sprinklers at truss-rod height; and 3) about 98% from LEPA (Low Energy Precision Application) systems that were operated perfectly.
- The 2% loss from the LEPA system was from soil evaporation during the day of application; the 8% loss from the sprinklers at truss rod height was 1% from droplet evaporation, 3% from canopy evaporation during water application, and 4% from canopy drying after application; the 15% loss from the sprinklers on top of the system was attributed to 3% from droplet evaporation and drift, 8% canopy evaporation during application, and 4% from canopy drying after application.
- The field of application was essentially flat; thus, runoff was minimal, and the losses during the experiment were attributed to evaporation.

The authors provided the below additional points since essentially all losses during the experiment were attributed to evaporation.

- Evaporative losses are the same regardless of the water application depth assuming the canopy is thoroughly wetted with each depth of water applied. Thus, when only 0.5 inch of water is applied, a 4% loss would be the same amount of water lost as when 1.0 or 2.0 inches are applied. However, the percentage of loss from a 0.5 inch application would be twice as great as that from a

1.0 inch application and four times as great as that from a 2.0 inch application.
- Evaporation of water from drops that travel through the air before reaching the crop canopy is strongly affected by the droplet size. In essence, larger drops are less affected by wind and evaporate at a much lower rate than smaller droplets.

The authors concluded that the water loss from above-canopy sprinklers to the soil is small and a small amount of runoff that causes water to move within a field [such as could occur if the standing crop interferes with the stability of sprinklers located within the canopy] will more than offset gains from locating sprinklers in the canopy. Thus, the primary objective for an overhead irrigation system sprinkler package should be to have the water applied uniformly across the field in order to achieve uniform infiltration into the soil–i.e. soil in all portions of an irrigated field should be uniformly wetted for maximum efficiency.

SPRINKLER PACKAGE DESIGN

Sprinkler packages for overhead irrigation systems should be designed to apply water uniformly and efficiently, while also being economically feasible. Items to consider when making a decision about which sprinkler design and placement follow.

System capacity. This is often limited by the water source, and the sprinkler package should account for this.

Wetted diameter of each sprinkler. This is the width water is applied by each individual sprinkler on the system. Its dimension should be large enough to minimize runoff across the irrigated field, but as small as possible to reduce evaporation. The system length affects the required wetted diameter of each sprinkler in regard to its location on the system.

System operating pressure and pressure regulators. Proper pressure is required to operate sprinklers correctly based on their design requirements. Remember that lower pressures will generally lower energy costs to operate the system. Operating pressure should take into account the level of foreign matter/debris in the irrigation water, and this can be coupled with choosing a filtration system that may allow for lower operating pressures.

Sprinkler spacing. Sprinklers should be spaced close enough to provide uniform water application, but as wide as possible to lower capital costs. Sprinkler design software should be used to determine the best spacing to achieve the highest uniformity. It is important to remember that if/when sprinklers are located within the crop canopy, the path of water droplets will be obstructed and the wetted diameter will be reduced. Thus, the spacing of sprinklers that are within the crop canopy must be decreased to achieve uniform application.

Sprinkler mounting height. The objectives when determining sprinkler mounting height are to 1) place them high enough to prevent the crop canopy from affecting the designed spray pattern, and 2) place them as close as possible to the top of the crop canopy to minimize drift and droplet evaporation. Remember that the wetted diameter of sprinklers will be decreased if they are placed closer to the ground.

Droplet Size. Important points to remember are 1) large droplets will have more impact on the soil surface, and 2) smaller droplets will be prone to increased drift and evaporation. Also remember that operating pressure of the system will affect droplet size.

Nozzle Size. Nozzle sizes along the path of the system should be determined by the sprinkler design software so that they are matched to the system capacity and sprinkler spacing. Ensure that individual sprinklers are installed at the correct location along the system pipeline so that they are in the correct order.

IN-CANOPY VS. ABOVE-CANOPY SPRINKLERS

The intent when using any overhead irrigation system is to apply water in the most uniform manner to the irrigated site while also ensuring the least evaporative loss during the irrigation. This has led to the continued debate of what is best–i.e. above-canopy or within-canopy application. Below are a list of some of the advantages and disadvantages of in-canopy sprinkler positioning.

Advantages

- Less wind drift loss.
- Less of the crop canopy is wetted, which reduces evaporation losses. This may not be as impactful as presumed since sprinklers may spray some of the applied water vertically when they are affected by their movement through the canopy.
- Their positive impact will be greatest in arid environments where evaporation losses will be highest.
- Their advantages will be larger with low-capacity systems that will run longer or more frequently, which will increase the opportunity for evaporative losses.
- The likely non-uniform application caused by the dragging-through-the-canopy effect on sprinklers makes them more practical on level and/or no-till fields that are less prone to within-field runoff.

Disadvantages

- Increased cost because of closer spaced sprinklers.
- Some vertical spraying of irrigation water resulting from being dragged back by the canopy.
- Possible sticking in the canopy as a result of entanglement with the canopy, which can result in increased canopy wetting, non-uniform application to the field, and potential local runoff within the field.
- Potentially higher maintenance costs because of their dragging through the crop canopy.
- Their out-of-sight position within the canopy will not allow visual monitoring for sprinkler malfunctions.

OTHER IMPORTANT POINTS TO CONSIDER

- Sprinkler devices on overhead systems do not last as long as the pivot or lateral-move systems themselves. Thus, they should be replaced as needed to ensure continued efficient operation.
- It is likely not practical or feasible to consider having sprinkler nozzles located inside a soybean canopy because soybean is much shorter than corn.
- Selecting a sprinkler configuration for overhead irrigation systems should be field-specific since the topography and soil properties of individual fields will be unique. Thus, a sprinkler package should be geared toward those properties since they will determine how much water can be applied with each irrigation event to ensure maximum uniformity and application efficiency and how each water application will be distributed across the field.

A Univ. of Nebraska publication titled "Center Pivot Irrigation Handbook" [EC3017] provides a comprehensive presentation about center pivot operation and performance, and selecting sprinkler packages that will ensure their most efficient use for the particular crop to be irrigated.

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